PB85-159044

Procedure for Certifying Quantity of Volatile Organic Compounds Emitted By Paint, Ink, and Other Coatings

(U.S.) Environmental Protection Agency
Research Triangle Park, NC

Dec 84

U.S. Department of Commerce
National Technical Information Service
NTIS

United States
Environmental Protection
Agency

Office of Air Quality
Planning and Standards
Research Triangle Park NC 27711

EPA-450/3-84-019
December 1984

Air

PB85-159044

EPA

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REPRODUCED BY
NATIONAL TECHNICAL
INFORMATION SERVICE
U.S. DEPARTMENT OF COMMERCE
SPRINGFIELD, VA. 22161

TECHNICAL REPORT DATA
(Please read Instructions on the reverse before completing)

1. REPORT NO.	2.	3. RECIPIENT'S ACCESSION NO.
EPA 450/3-84-019		PB85 159044/AS

4. TITLE AND SUBTITLE	5. REPORT DATE
Procedures for Certifying Quantity of Volatile Organic Compounds Emitted by Paint, Ink, and Other Coatings	December 1984
	6. PERFORMING ORGANIZATION CODE
7. AUTHOR(S)	8. PERFORMING ORGANIZATION REPORT NO.
9. PERFORMING ORGANIZATION NAME AND ADDRESS Office of Air Quality Planning and Standards U. S. Environmental Protection Agency (MD-13) Research Triangle Park, NC 27711	10. PROGRAM ELEMENT NO.
	11. CONTRACT/GRANT NO.
12. SPONSORING AGENCY NAME AND ADDRESS SAME AS BOX 9	13. TYPE OF REPORT AND PERIOD COVERED
	14. SPONSORING AGENCY CODE EPA/200/04

15. SUPPLEMENTARY NOTES

16. ABSTRACT

This manual provides procedures by which firms may voluntarily certify the quantity of volatile organic compounds which will be emitted by a paint, ink, or other coating. Two data sheets are provided. One is to be used by the manufacturer of the coating, the other by the user. Analytical test methods and procedures for preparing the data sheets are included, as are the equations and instructions necessary to convert the analytical results into a format suitable for determining compliance with State or Federal regulations.

17. KEY WORDS AND DOCUMENT ANALYSIS

a. DESCRIPTORS	b. IDENTIFIERS/OPEN ENDED TERMS	c. COSATI Field/Group
Air Pollution Coatings Compliance Calculations Pollution Control Reference Method 24 Test Methods Volatile Organic Compounds	Air Pollution Control	13-B

18. DISTRIBUTION STATEMENT	19. SECURITY CLASS *(This Report)*	21. NO. OF PAGES
	Unclassified	15
	20. SECURITY CLASS *(This page)*	22. PRICE
	Unclassified	

EPA Form 2220-1 (Rev. 4-77) PREVIOUS EDITION IS OBSOLETE

EPA-450/3-84-019

Procedure for Certifying Quantity of Volatile Organic Compounds Emitted By Paint, Ink, and Other Coatings

Emission Standards and Engineering Division

U.S. ENVIRONMENTAL PROTECTION AGENCY
Office of Air and Radiation
Office of Air Quality Planning and Standards
Research Triangle Park, North Carolina 27711

December 1984

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PREFACE

This manual was conceived as a way to provide simple step-by-step instructions for certifying the quantity of volatile organic compounds (VOC) that will be released by a coating. It has not turned out that way. The guidance is here, but in spite of great diligence, the instructions remain imposing.

The manual was prepared for several reasons. First, the coatings industry, as represented by the National Paint and Coatings Association, had requested a certification procedure which would relieve their customers the expense of analysis. Second, the complexity of the calculations necessary to determine compliance, for example, when dilution solvent is added to a coating, continue to confound Federal, State and Local enforcement personnel. Finally, results of a recent review of the Agency's reference method for determining VOC reemphasized the importance of analytical procedures to verify VOC content.

In response to the results of the review of the test methods, this manual reaffirms that Reference Method 24 or its constituent methods developed by the American Society for Testing and Materials (ASTM), are the procedures by which the VOC content of a coating will be determined for compliance with Federal regulations. The earliest guidance was not so specific. In 1977, the first report[1], written to assist States in developing regulations for sources of VOC emissions, provided recommendations for the maximum allowable VOC content for complying coatings in a variety of industries. These values were expressed in mass of VOC per unit volume of coating. In deriving the recommended limitation, the VOC content of a coating was calculated based on the solids content provided by the coating manufacturer. The Agency calculated the mass of VOC in the coating by assuming the VOC had a density of 7.36 pounds per gallon.

Solvent and VOC were used somewhat interchangebly even though it was recognized that organics such as resin monomer, oligimers, and reaction by-products could be released by a coating during the cure. There was no accepted analytical method available for measuring the total VOC which would be released by a coating. The initial guidance[1] provided an analytical method for use only for air-dry coatings, those where all VOC emissions would be expected to come as a result of evaporation of solvent. On a volume basis, air dry coatings constituted the largest catagory of coatings then in use.

The Agency subsequently developed a more general analytical procedure that could be used to determine the total VOC in a coating. On October 3, 1980, the Agency published "Reference Method 24 (RM-24) -

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[1]Control of Volatile Organic Emissions from Stationary Sources - Volume II: Surface Caoting of Cans, Coils, Paper, Fabrics, Automobiles, and Light-duty Trucks, Document No. EPA-450/2-77-008.

Determination of Volatile Matter Content, Density, Volume Solids, and Weight Solids of Surface Coatings," in the Federal Register (45 FR 65958). For the first time the Agency formally specified an analytical method for the VOC content of those coatings that cure by chemical reaction. Even then, the announcement continued to allow the manufacturer's formulation to be used to calculate the VOC content but specified that the analytical technique, RM-24, would be the reference in any conflict between the two.

During 1981 and 1982, as more State and Federal regulations were established, the demand for low-solvent coatings began a continuing increase in the sales volume of reaction-cure coatings. There was some concern voiced by the industry in how appropriate the reference method was for these type coatings. To find out, the Agency began a review of RM-24 to determine the effect of temperature and exposure time on the indicated VOC "content". It was concluded that the maximum effect of those time-temperature combinations that were examined amounted to only about a 10 percent variation. Somewhat more surprising was that the solvent sometimes accounted for only 50 to 70 percent of the total VOC measured by the reference method.

The obvious conclusion was that RM-24 is a better measure of the total organics freed by a coating than is the solvent. This manual implements a policy based on that conclusion. Certification of VOC content on the attached Data Sheets must be based on an analysis using RM-24. No longer will solvent content be permitted as a surrogate for VOC unless a showing is first made that its use is a reasonable alternative or equivalent method of determining the VOC content of that particular coating.

One final comment. Since VOC is not always synonomous with solvent, it follows that the amount of solids in a coating cannot be obtained by subtracting the solvent from the total volume of coating. The original Federal Register proposal for RM-24, published on October 3, 1980, recommended the American Society of Test Materials test Number D2697 as the appropriate method of determining solids content. Subsequent comments from the industry maintained that this test is unreliable. As a result, when promulgated in 1980, RM-24 specified that the solids content of a coating can be obtained only from the manufacturer's formulation of the coating.

Dennis Crumpler

Dennis Crumpler
December 14, 1984

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GLOSSARY OF TERMS

"As Applied"	the condition of a coating after dilution by the user just prior to application to the substrate.
"As Supplied"	the condition of a coating before dilution, as sold and delivered by the coating manufacturer to the user.
$(D_c)_a$	coating density "as applied"
$(D_c)_s$	coating density, "as supplied"
D_d	density of dilution solvent
$D_d^{\dagger}$	density of organic solvent/water mixture
D_w	density of water (8.33 lb/gal)
R_d	dilution solvent ratio, equals the volume of VOC added per unit volume of coating "as supplied"
$R_d^{\dagger}$	equals the volume of premixed water and VOC added per unit volume of coating "as supplied"
$(V_n)_a$	Volume percent solids of coating "as applied"
$(V_n)_s$	Volume percent solids of coating "as supplied"
$(VOC)_a$	VOC content of "as applied" coating, expressed as mass of VOC per unit volume of coating less water or as mass of VOC per unit volume of solids
$(VOC)_s$	VOC content of "as supplied" coating, expressed as mass of VOC per unit volume of coating less water or as mass of VOC per unit volume of solids
$(V_w)_a$	the water content, in volume percent, of coating "as applied"
$(V_w)_d$	the water content, in volume percent, of the dilution solvent added to the "as supplied" coating
$(V_w)_s$	the water content, in volume percent, of the coating "as supplied"
$(W_o)_a$	the organic volatile content, in weight percent, of the coating "as applied"
$(W_o)_s$	the organic volatile content, in weight percent, of the coating "as supplied"

$(W_v)_a$	the weight percent of total volatiles in the coating "as applied"
$(W_v)_s$	the weight percent of total volatiles in the coating "as supplied"
$(W_w)_a$	the weight percent water in the coating "as applied"
$(W_w)_d$	the weight percent water in the dilution solvent
$(W_w)_s$	the weight percent water in the coating "as supplied"

1. INTRODUCTION

This Manual provides step-by-step instruction for preparation of two data sheets developed by the Environmental Protection Agency which may be used by coating manufacturers and users to present information on the quantity of volatile organic compounds* (VOC) emitted from a coating. One of the data sheets may be prepared by the manufacturer of the coating; the second would be used by the company that applies the coating to a substrate.

The first VOC data sheet, which would be prepared by the manufacturer, provides information on the volatile organic content of a coating as it is delivered to a customer. This is referred to as the VOC content of the coating "as supplied" (by the manufacturer to the user).

The second VOC data sheet, which would be prepared by the user or coater, provides information on the quantity of volatile organic compounds present as the coating is used or applied to the substrate and includes the effect of any dilution solvent added before application. This is referred to as the VOC content of the coating "as applied" (to the substrate).

The coating user may submit, and the Agency enforcing a regulation may accept, these data sheets as prima facie evidence of the actual VOC content of a coating. The referee method for ultimate determination of compliance, however, will continue to be the method specified in the applicable regulation (for example, EPA Reference Method 24 or individual ASTM methods).

*Volatile Organic Compound (VOC) - Any organic compound which participates in atmospheric photochemical reactions; that is, any organic compound other than those which the Administrator designates as having negligible photochemical reactivity. VOC may be measured by a reference method, an equivalent method, an alternative method, or by procedures specified under any regulation.

2. VOC CONTENT OF PAINT, INK AND OTHER COATINGS "AS SUPPLIED" BY THE COATING MANUFACTURER TO THE USER

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY

VOC DATA SHEET:

PROPERTIES OF THE COATING "AS SUPPLIED" BY THE MANUFACTURER

Coating Manufacturer: _____

Coating Identification: _____

Batch Identification: _____

Supplied To: _____

Properties of the coating as supplied[1] to the customer:

A. Coating Density $(D_C)_S$: _____ lb/gal _____ kg/l

☐ ASTM D1475 ☐ Other[2]

B. Total Volatiles $(W_V)_S$: _____ Weight Percent

☐ ASTM D2369 ☐ Other[2]

C. Water Content: 1. $(W_W)_S$ _____ Weight Percent

☐ ASTM D3792 ☐ ASTM D4017 ☐ Other[2]

2. $(V_W)_S$ _____ Volume Percent

☐ Calculated ☐ Other[2]

D. Organic Volatiles $(W_O)_S$: _____ Weight Percent

E. Nonvolatiles Content $(V_n)_S$: _____ Volume Percent

F. VOC Content $(VOC)_S$: 1. _____ lb/gal coating less water

or _____ kg/l coating less water

2. _____ lb/gal solids

or _____ kg/l solids

Remarks: (use reverse side)

_____

[1]The subscript "s" denotes each value is for the coating "as supplied" by the manufacturer.

[2]Explain the other method used under "Remarks".

Signed: _____ Date _____

2.2 IMPLEMENTING INSTRUCTIONS FOR THE VOC DATA SHEET FOR "AS SUPPLIED" COATINGS

This DATA SHEET is normally completed by the coating manufacturer and provided to the user.[1] It will henceforth be referred to as the "AS SUPPLIED" VOC DATA SHEET.

A. The "as supplied" coating density, $(D_c)_s$[2], is determined using "ASTM D1475 - Standard Test Method for Density of Paint, Lacquer, and Related Products."

B. The weight percent of total volatiles in a coating, $(W_v)_s$, is determined by "ASTM D2369 - 81 Standard Method for Volatile Content of Coatings." drying conditions to be used are 110°C for 1 hour[3].

C. Water Content

1. The weight percent water, $(W_w)_s$, is determined by "ASTM D3792 - Standard Test Method for Water Content of Water-Reducible Paints by Direct Injection Into a Gas Chromatograph," or "ASTM D4017 - Standard Test Method for Water in Paints and Paint Materials by the Karl Fischer Method."[3,4] An acceptable alternative to these procedures for purposes of preparing the data sheet would be to calculate the weight percent water from the manufacturer's coating formulation.

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[1]EPA's Reference Method 24 (40 C.F.R. Part 60, App. A), contains the ASTM methods referenced in these instructions.

[2]The subscript "s" denotes those parameters of a coating when measured in the "as supplied" condition, before dilution by the user.

[3]If the manufacturer believes a specified method does not give results that are representative of the actual cure mechanism, he may petition the enforcement authority for approval of an alternate analytical method. Any alternate method or alteration to the methods and procedures in these instructions or in any applicable regulation would be subject to review and approval by the appropriate State and Federal enforcement agency.

[4]Volatile compounds classified by EPA as having negligible photochemical reactivity such as 1,1,1-trichloroethane and methylene chloride, etc., and listed as exempt in the applicable Federal and State VOC regulation should be treated in the same manner as water. The weight percent of negligibly reactive compounds in a coating should be determined from the manufacturer's formulation. The volume percent can then be calculated using equation II-1 when the weight percent and density of the negligibly reactive compounds are substituted for those of water. The weight and volume percent can be used in Equations II-2 and II-6, respectively, in place of $(W_w)_s$ and $(V_w)_s$.

2. The water content, in volume percent, $(V_w)_s$, can be calculated by the equation:

$$(V_w)_s = \frac{(W_w)_s (D_c)_s}{D_w}, \qquad \text{II-1}$$

where D_w is the density of water, 8.33 lbs/gal.

D. The organic volatiles content, $(W_o)_s$, i.e., the VOC content expressed as a percent by weight, is determined by the following equation[5]:

$$(W_o)_s = (W_v)_s - (W_w)_s \qquad \text{II-2}$$

If the coating contains no water the weight percent of organic volatiles is equal to the weight percent of total volatiles.

In other words:

$(W_w)_s = 0$ and

$$(W_o)_s = (W_v)_s \qquad \text{II-3}$$

E. The volume percent solids (nonvolatiles), $(V_n)_s$, should be derived from the coating formulation using the following equation:

$$(V_n)_s = \sum_{i=1}^{p} (V_n)_{s_i} \qquad \text{II-4}$$

where $(V_n)_{s_i}$ denotes the volume percent of each nonvolatile component in an "as supplied" coating, and "p" is the number of nonvolatile components in that coating. (Also see Footnote 1, Pg. II-3.)

---

[5]The precision limit adjustments permitted by Reference Method 24 for experimentally determined mean W_w and W_v values may be made only by enforcement agencies for determination of compliance. The adjustment is not to be used for the purposes of completing the "AS SUPPLIED" VOC DATA SHEET.

F. The VOC content of the "as supplied" coating $(VOC)_s$ can now be calculated and thereby expressed in terms used by most State or Federal regulations.

1. The mass of VOC per unit volume of coating less water:

   a. If the coating contains no water, the equation is calculated as follows:

$$(VOC)_s = \frac{(W_o)_s\,(D_c)_s}{100\%} \qquad \text{II-5}$$

   b. If the coating contains water, Equation II-5 becomes:

$$(VOC)_s = \frac{(W_o)_s\,(D_c)_s}{100\% - (V_w)_s} \qquad \text{II-6}$$

2. The VOC content may also be calculated in terms of mass of VOC per unit volume of solids (nonvolatiles). For both solvent-borne and waterborne coatings, the equation is:

$$(VOC)_s = \frac{(W_o)_s\,(D_c)_s}{(V_n)_s} \qquad \text{II-7}$$

3. VOC CONTENT OF PAINT, INK AND OTHER COATINGS "AS APPLIED" TO THE SUBSTRATE BY THE USER

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY

VOC DATA SHEET:

PROPERTIES OF THE COATING "AS APPLIED" TO THE SUBSTRATE

Coating Manufacturer: _____

Coating Identification: _____

Batch Identification: _____

User: _____

User's Coating Identification: _____

Properties of the coating as applied[1] by the User:

A. Coating Density $(D_c)_a$: _____ kg/l, or _____ lb/gal

☐ ASTM D1475 ☐ Other[2]

B. Total Volatiles $(W_v)_a$: _____ Weight Percent

☐ ASTM D2369 ☐ Other[2]

C. Water Content: 1. $(W_w)_a$ _____ Weight Percent

☐ ASTM D3792 ☐ ASTM D4017 ☐ Other[2]

2. $(V_w)_a$ _____ Volume Percent

☐ Calculated ☐ Other[2]

D. Weighted Average Density of the dilution solvent (D_d)[3]: _____ lb/gal

☐ ASTM D1475 ☐ Handbook ☐ Formulation

(Continued on Reverse Side)

[1]The subscript "a" denotes each value is for the coating "as applied" to the substrate.
[2]Explain the other method used under "Remarks" on reverse side
[3]The subscript "d" denotes values are for the dilution solvent

E. Dilution Solvent Ratio (R_d): _____ $\frac{\text{gal diluent}}{(\text{gal coating})_s}$[4]

or

_____ $\frac{\text{liter diluent}}{(\text{liter coating})_s}$[4]

F. Organic Volatiles Content[5] $(W_o)_a$: _____ Weight Percent

G. Non-Volatiles Content $(V_n)_a$: _____ Volume Percent

H. VOC Content $(VOC)_a$: 1. _____ lb/gal of coating less water

or _____ kg/l of coating less water

2. _____ lb/gal solids

or _____ kg/l solids

REMARKS:

Signed: _____ Date: _____

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[4]The subscript "s" denotes values are for the coating "as supplied" by the manufacturer.

[5]This terminology is used to be consistent with Method 24. It refers to all photochemically reactive organic compounds emitted from the coating including reactive by-products of the cure reaction, exactly the same matter as indicated in Paragraph H, i.e., volatile organic compounds, or VOC.

3.2. IMPLEMENTING INSTRUCTIONS FOR THE VOC DATA SHEET FOR "AS APPLIED" COATINGS

This DATA SHEET, henceforth referred to as the "AS APPLIED" VOC DATA SHEET, is to be completed by the company which applies a coating. It provides information on the amount of volatile organic compounds (VOC) in the coating "as applied" to the substrate by accounting for the quantity of diluent solvent added to a coating prior to application. There are two avenues available for the coater to certify the VOC content. One is to analyze each diluted coating with the same method used to generate the data provided by the coating manufacturer on the "AS SUPPLIED" VOC DATA SHEET. (See Chapter 2 of this Manual.) In this case begin with Step A.[1] The other is to maintain adequate records of how much organic solvent is added to each coating and use that information and the "AS SUPPLIED" VOC DATA SHEET[2] to calculate the VOC content "as applied." (The user may choose to analyze an "As Supplied" coating using Reference Method 24 and complete the "AS SUPPLIED" VOC DATA SHEET rather than have the coating manufacturer complete it. The volume percent solids, however, will necessarily continue to be supplied by the coating manufacturer.) In this case begin with Step D. If a coating is diluted only with water or a solvent of negligible photochemical reactivity, skip Steps A through D below and proceed directly to E. (Also see Footnote 4, Pg. III-5.)

A. The "as applied" coating density, $(D_c)_a$[2], is determined using "ASTM D1475-Standard Test Method for Density of Paint, Lacquer, and Related Products."

B. The weight percent of total volatiles in the coating, $(W_v)_a$ is determined by "ASTM D2369-81 Standard Method for Volatile Content of Coatings." The drying conditions to be used are 110°C for 1 hour[3].

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[1]EPA's Reference Method 24 (40 C.F.R. Part 60, App. A), contains the ASTM methods referenced in these instructions.

[2]The subscript "a" denotes those parameters of a coating in the "as applied" condition, i.e., after dilution by the user. The subscript "s" denotes the parameters of a coating in the "as supplied" condition, before dilution by the user.

[3]If the manufacturer believes the specified method gives results that are not representative of the VOC released during the normal cure, he may petition the enforcement authority for approval of an alternative analytical method. Any alternate method or alteration to the methods and procedures in these instructions or in any applicable regulation would be subject to review and approval by the appropriate State and/or Federal enforcement agency.

C. The water content is necessary only if the coating has been diluted with a mixture of organic solvent and water.[4],[5] If the dilution solvent is 100 percent organic, or if the weight and volume percent water in the mixture is known, proceed directly to Step D.

The weight percent water, $(W_w)_a$, is determined by "ASTM D3792 - Standard Test Method for Water Content of Water-Reducible Paints by Direct Injection Into a Gas Chromatograph," or "ASTM D4017 - Standard Test Method for Water in Paints and Paint Materials by the Karl Fischer Method." (Also see Footnote 3, Pg. III-4.)

The water content, in volume percent, $(V_w)_a$, can be calculated by the equation:

$$(V_w)_a = \frac{(W_w)_a \ (D_c)_a}{D_w} \qquad \text{III-1}$$

where D_w is the density of water, 8.33 lb/gal.

---

[4]Volatile compounds classified by EPA as having negligible photochemical reactivity such as 1,1,1-trichloroethane and methylene chloride, etc., and listed as exempt in the applicable Federal and State VOC regulation, should be treated in the same manner as water. The weight percent of negligibly reactive compounds in the dilution solvent must be known either from the coater's mixing records or the dilution solvent supplier's formulation. The volume percent can then be calculated using Equations III-1 or III-5 when the weight percent and density of the negligibly reactive organics are substituted for those of water. The weight and volume percent of the negligibly reactive compounds can be substituted in all equations where the weight and volume percent water, (W_w) and (V_w), respectively, are used.

[5]The precision limit adjustments permitted by Reference Method 24 for experimentally determined mean weight percent water and total volatiles, W_w and W_v respectively, may be made only by enforcement agencies for determination of compliance. The adjustment is not to be used for the purposes of completing the "AS APPLIED" VOC DATA SHEET.

D. If the dilution solvent consists of a single compound the density may be obtained from the literature.

If the dilution solvent is a mixture of organic compounds, the density, D_d[6], can be determined analytically via ASTM D1475, or an average density can be estimated from the solvent formulation as shown below. This estimation assumes that volumes are additive.

$$D_d = \frac{100\%}{\sum_{j=1}^{m} \frac{W_j}{D_j}} \qquad \text{III-2}$$

or

$$= \frac{1}{100\%} \sum_{j=1}^{m} V_j D_j \qquad \text{III-3}$$

where: D_j, W_j, and V_j denote the density, weight percent, and volume percent of each solvent in the dilution solvent mixture and "m" is the number of organic solvents in the dilution solvent mixture.

If the dilution solvent is a mixture of photochemically reactive organics and water, the coater must know the weight percent, $(W_w)_d$, or volume percent, $(V_w)_d$, of water from his mixing records or the supplier's formulation, or he must analytically determine the weight fraction of water in the dilution solvent using ASTM D3792 or ASTM D4017. The density, D_d, of the dilution solvent may then be determined by analytically measuring the density of the organic solvent/water mixture, $D_d^{\dagger}$, using ASTM D1475 and adjusting it for the water content using the following equation. (See also Footnote 4, Pg. III-5.)

$$D_d = D_d^{\dagger} \frac{[100\% - (W_w)_d]}{[100\% - (V_w)_d]} \qquad \text{III-4}$$

Note: If either the weight or volume percent water in the dilution solvent is known, the other can be calculated by the equation:

$$(V_w)_d = \frac{(W_w)_d \; D_d^{\dagger}}{D_w} \qquad \text{III-5}$$

where "D_w" is the density of water.

---

[6]The subscript "d" denotes a parameter that pertains to that solvent used by the coater to dilute the "as supplied" coating.

E. The dilution solvent ratio, R_d, is defined as the volume of photochemically reactive organic solvent, (VOC), added per unit volume of "as supplied" coating. Stated mathematically,

$$R_d = \frac{\text{Volume photochemically reactive dilution solvent added}}{\text{Volume of "as supplied" coating}}$$

1. If the "as supplied" coating is subsequently diluted with water or a solvent which is of negligible photochemical reactivity, the VOC content will be unchanged from that reported on the "AS SUPPLIED" VOC DATA SHEET. This should be reported on the "AS APPLIED" VOC DATA SHEET by entering "0" for the dilution solvent ratio, R_d.

2. In the absence of adequate dilution records, R_d can be calculated from entries on the VOC DATA SHEETS by one of the following equations:

   a. When the dilution solvent consists only of VOC,

$$R_d = \frac{(D_c)_s - (D_c)_a}{(D_c)_a - (D_d)} \qquad \text{III-6}$$

   b. When the dilution solvent is a mixture of water and photochemically reactive organic solvent, Equation III-6 may be expressed as:

$$R_d^{\dagger} = \frac{(D_c)_s - (D_c)_a}{(D_c)_a - (D_d)^{\dagger}} \qquad \text{III-7}$$

   where: $R_d^{\dagger}$ is the ratio of the volume of water and organic dilution solvent to the volume of "as supplied" coating to which it is added. (Also see Footnote 4, Pg. III-5.)

The dilution solvent ratio, R_d, may now be calculated from $R_d^{\dagger}$ by the following equation:

$$R_d = R_d^{\dagger} \left[1 - \frac{(V_w)_d}{100\%}\right] \qquad \text{III-8}$$

F. The organic volatile content $(W_o)_a$, i.e. the VOC content expressed as a percent by weight of the diluted coating, can now be calculated by either of two ways:

1. From analyses of the coating using the following equation:

$$(W_o)_a = (W_v)_a - (W_w)_a \qquad \text{III-9}$$

(See Footnotes 4 and 5, Pg. III-5.)

If the coating does not contain water, the weight percent of organic volatiles is equal to the weight percent of total volatiles, or

$$(W_o)_a = (W_v)_a \qquad \text{III-10}$$

2. By using the data from the "AS SUPPLIED" VOC DATA SHEET, the dilution solvent ratio, and the density of the dilution solvent with the following equation:

$$(W_o)_a = \frac{[(D_c)_s\ (W_o)_s/100\%] + (R_d D_d)}{(D_c)_s + (R_d D_d)} \times 100\% \qquad \text{III-11}$$

G. The volume percent solids, or nonvolatiles, $(V_n)_a$, must be calculated from the following equation where $(V_n)_s$ is obtained from the "AS SUPPLIED" VOC DATA SHEET.

$$(V_n)_a = \frac{(V_n)_s}{1 + R_d} \qquad \text{III-12}$$

H. The VOC content of the "as applied" coating $(VOC)_a$, can now be calculated and thereby expressed in terms used in most State or Federal regulations.

1. The mass of VOC per unit volume of coating, less water, is calculated in either of two ways.

a. Using the results obtained by analyzing the coating with EPA Reference Method 24 or its constituent ASTM Methods:

(1). If the coating contains no water the equation is:

$$(VOC)_a = \frac{(W_o)_a\ (D_c)_a}{100\%} \qquad \text{III-13}$$

(2). If the coating contains water the following equation must be used:

$$(VOC)_a = \frac{(W_o)_a\ (D_c)_a}{100\% - (V_w)_a} \qquad \text{III-14}$$

b. Using the VOC content of the "as supplied" coating, (VOC_s), the dilution solvent ratio, and the density of the solvent, the equation is:

$$(VOC)_a = \frac{[(VOC)_s\ (100\% - (V_w)_s)/100\%] + (R_d D_d)}{1 + R_d} \qquad \text{III-15}$$

Where $(VOC)_s$ in this case must be in units of lbs VOC/gal coating less water.

2. The VOC content may also be calculated in terms of mass of VOC per unit volume of solids (nonvolatiles).

a. Using the results obtained by analyzing the coating with EPA Reference Method 24 or its constituent ASTM methods, the equation for both solvent-borne and waterborne coatings, is:

$$(VOC)_a = \frac{(W_o)_a\ (D_c)_a}{(V_n)_a} \qquad \text{III-16}$$

b. Using dilution information and calculation procedures only, the equation is:

$$(VOC)_a = \frac{[(VOC)_s\ (100\% - (V_w)_s)/100\%] + (R_d D_d)}{(V_n)_s/100\%} \qquad \text{III-17}$$

Where $(VOC)_s$ in this case must be in units of lbs VOC/gal coating less water.